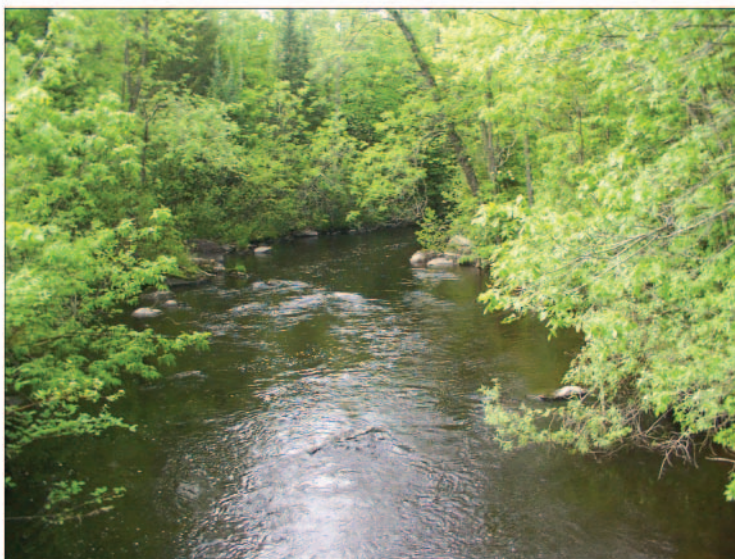


Surface-Water-Resources Information for the Ho-Chunk Nation Lands and Vicinity, Wisconsin



Middle Branch Embarrass River

Prepared in cooperation with the Ho-Chunk Nation



Water-Resources Investigations Report 02–4307

**U.S. Department of the Interior
U.S. Geological Survey**

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By Matthew W. Diebel and Daniel J. Sullivan



Prepared in cooperation with the Ho-Chunk Nation

Water-Resources Investigations Report 02–4307

Middleton, Wisconsin: 2003

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Conversion Factors, Datums, and Abbreviated Water-Quality Units

Multiply	By	To Obtain
foot (ft)	3.2808	meter
mile (mi)	1.6093	kilometer
acre	0.004047	square kilometer
square mile (mi ²)	2.59	square kilometer
cubic feet per second (ft ³ /s)	0.02583	cubic meter per second

Datums: Horizontal coordinate information is referenced to the North American Datum of 1983 (1991 adjustment).

Abbreviated water-quality units used in this report: Some water quality constituent concentrations are given in milligrams per liter (mg/L), which expresses the concentration of a chemical constituent in solution as weight (milligrams) of solute per unit volume (liter) of water. Specific conductance is given in microsiemens per centimeter ($\mu\text{S}/\text{cm}$), which expresses the electrical conductivity measured between opposite faces of a centimeter cube of water.

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Surface-Water-Resources Information for the Ho-Chunk Nation Lands and Vicinity, Wisconsin

By Matthew W. Diebel and Daniel J. Sullivan

Abstract

The Ho-Chunk Nation is interested in documenting water-quality conditions in streams adjacent to their Reservation lands in Wisconsin and developing management plans to protect these water resources. The Nation uses these waterways for recreation and as a source for food, and therefore, is dedicated to maintaining and restoring their quality. Ho-Chunk lands encompass more than 10,000 acres ranging primarily over 17 counties in Wisconsin. The study areas for this report include streams adjacent to Ho-Chunk Nation residential lands: Potch-Hah-Chee, Sandpillow, Mission, Bluewing, Chakh Hah Chee, Winnebago Heights, Indian Heights, and Ho-Chunk Village. These residential areas, or housing sites, are located along or near the Middle Branch Embarrass, Black, Lemonweir, and Wisconsin Rivers or their tributaries.

Water-quality data were compiled and summarized, and basin maps showing land cover and previous sampling sites are presented. Qualitative assessments of factors that could potentially affect water quality were summarized from the literature. Quantitative data were available from several studies (more than 5) for the Potch-Hah-Chee area, few studies (1–5) for the Sandpillow, Mission, Ho-Chunk Village, and Indian Heights areas, and no studies for the Bluewing, Chakh Hah Chee, and Winnebago Heights areas. Data analysis was limited to averaging basic water-quality constituents for the Middle Branch Embarrass River in the Potch-Hah-Chee area. The mainstem Wisconsin and Black Rivers have been extensively studied elsewhere and are not independently re-evaluated here.

Qualitative assessments indicate that agricultural activities are the main contributing factor to water quality and fish habitat problems in the studied areas. Index of Biotic Integrity ratings, based on fish data, were available for 5 sites on 3 streams. Hilsenhoff Biotic Index ratings, based on macroinvertebrate data, were available for 21 sites on 4 streams. This information will serve as baseline data and as a guide to ongoing study and management of these waters by the Ho-Chunk Nation.

Introduction

Water resources are an important part of the cultural heritage of the Ho-Chunk Nation, and tribe members continue to use waterways for recreation and as a food source. The tribal government is therefore striving to better understand and manage these resources. This effort includes an investigation of the condition of the rivers and streams that flow through or adjacent to their residential lands. The Ho-Chunk Nation and the U.S. Geological Survey (USGS) entered into a cooperative agreement to (1) produce a retrospective summary and analysis of existing information regarding surface-water resources and (2) collect and analyze baseline surface-water-quality samples to augment historical data. This report fulfills the first objective. The collection of baseline water-quality data, the second objective, began in 2002.

This report summarizes available information related to surface-water resources on and in the immediate vicinity of housing sites of the Ho-Chunk Nation. The studies and data included in this report are based on a review of the literature and data bases that were available through standard literature searches and contacts with various local, State, and Federal agencies and academic institutions. Some studies that are not referred to in the text of this report are included in the references section because they were deemed potentially relevant to future management efforts.

Water-Resources-Related Information for Ho-Chunk Housing Sites

The residential lands of the Ho-Chunk Nation are in central Wisconsin, within the watersheds of the Wolf, Black, and Wisconsin Rivers (fig. 1). Their geographic and hydrologic settings are diverse; consequently, they will be treated separately in this report. Table 1 summarizes locations of housing sites and associated streams,

and notes whether water-quality data exist for relevant stream reaches. Table 2 describes previous studies that contain water-resources information related to these housing sites.

Potch-Hah-Chee

The Potch-Hah-Chee housing site is along the Middle Branch Embarrass River, north of the Village of Wittenberg, in Shawano County (fig. 2). The Middle Branch Embarrass River has an average width of 37 ft, is 43.4 mi long, and drains 157 mi² (Ball and Doegler, 1986). Major land-cover types are forest (31.0 percent), agriculture (25.2 percent), wetland (24.1 percent), and grassland (18.6 percent) (fig. 3). The USGS has operated a streamflow-monitoring station (USGS station 0407809265) 3 mi downstream of Potch-Hah-Chee since 1989. The mean annual streamflow at this station between 1990 and 2000 was 62.4 ft³/s. The Middle Branch Embarrass River drains 73.8 mi² where it enters the housing site. Packard Creek drains 21.3 mi² before flowing into the Middle Branch Embarrass River 0.4 mi upstream of Potch-Hah-Chee.

The Middle Branch Embarrass River supports a coldwater sport fishery of brook (*Salvelinus fontinalis*) and brown (*Salmo trutta*) trout, which were studied by the Wisconsin Department of Natural Resources (WDNR) in 1974 (Ball and Doegler, 1986). Basic water-quality measurements were also taken at that time (table 3). Potential water-quality problems described in this report were associated with cattle pasturing along streambanks, which caused erosion and a resultant loss of habitat for trout in the upper reaches of the stream.

In 1980, sampling for macroinvertebrates was done at eight sites along the Middle Branch Embarrass River and Packard Creek (table 3, sites 2, 4, 10, 14–18). Sampling was repeated in 1985 and 1991 at two sites (table 3, sites 6 and 9) to assess the effect of the Village of Wittenberg's change of sewage treatment effluent discharge to the Middle Branch Embarrass River in 1989 (Ball and Doegler, 1986). Hilsenhoff Biotic Index (HBI)¹ ratings from sites with multi-year sampling ranged from "fair" to "excellent," but indicated no trends over time. In 1985, habitat measurements were taken and the resulting habitat evaluation indicated excellent habitat (Mary Gansberg, Wisconsin Department of Natural Resources, written commun., 2002).

Water-quality data collected from the Middle Branch Embarrass River between 1974 and 1995 (table 3) were used to calculate mean concentrations but were not useful for trend analysis. Average pH was 8.15. Average alkalinity was 187 mg/L and average specific conductance was 321 µS/cm, both of which indicate hard water. Average total nitrogen concentration was 0.58 mg/L. Average total phosphorus concentration was 0.028 mg/L, which is below the limit of 0.1 mg/L recommended by the U.S. Environmental Protection Agency to discourage excessive biotic growth in flowing water (U.S. Environmental Protection Agency, 1986). Suspended-sediment concentrations were low, averaging 7.6 mg/L.

Sandpillow and Mission

The Sandpillow and Mission housing sites are in the Morrison Creek watershed, near its confluence with the



Packard Creek



Middle Branch Embarrass River

¹ Biotic indices such as the HBI are used to produce categorical water-quality ratings based on analysis of the biotic community structure (Hilsenhoff, 1977).



Dickey Creek



Valentine Creek



Morrison Creek

Black River (fig. 4). Dickey Creek and Valentine Creek are major tributaries to Morrison Creek that flow through Ho-Chunk housing sites. Major land-cover types in the Morrison Creek watershed are forest (64.2 percent) and wetland (24.2 percent) (fig. 5).

Dickey Creek is a small stream (10 mi long, 15 ft wide in lower reaches) that is on the WDNR's 303(d) list of impaired waters due to warming of stream temperatures. The uppermost reaches are considered to have the potential to support a class II trout fishery, but the waters are warmed by hydrologic manipulation (dams) (Wisconsin Department of Natural Resources, 1998b) and thus currently support only a warmwater forage fishery.

Valentine Creek is a very small stream (3 mi long, 8 ft wide in lower reaches) that contains naturally reproducing brook trout and is classified as an exceptional resource water by the WDNR (code NR102) (Wisconsin Department of Natural Resources, 1998b). Monitoring records for this stream include a summer-long temperature profile and fish population and habitat assessments (table 4, sites 5 and 6) (Avery, 1997). Index of Biotic Integrity for Coldwater Streams (CWIBI) (Lyons and others, 1996) ratings were "good" at site 6 and "fair" at site 5. Fish Habitat Ratings (FHR) (Simonson and others, 1994) were "good" at site 6 and "excellent" at site 5.

Morrison Creek flows for 30 mi and drains 130 mi² before its confluence with the Black River. The stream supports only forage fish most of its length; the terminal 8 mi are classified as a warmwater sport fishery. Macro-invertebrates were sampled from Morrison Creek at an undetermined site in the Black River State Forest; sampling results indicated signs of some organic pollution (Wisconsin Department of Natural Resources, 1992b). Numerous cranberry bogs exist in the Morrison Creek watershed, which may affect its flow and water quality (Avery, 1997; Greb and others, 1999; Schreiber, 1993, 1988). The impoundments associated with cranberry farming have fewer negative effects on the warmwater fisheries typical of this watershed than on the coldwater fisheries

in other nearby watersheds (Wisconsin Department of Natural Resources, 1998b). There are several endangered or threatened aquatic-dependent animal species in the Morrison Creek watershed, including the warpaint emerald (*Somatochlora incurvata*), an aquatic insect, and the wood turtle (*Clemmys insculpta*) (Wisconsin Department of Natural Resources, 1998b).

The Black River is a large stream that flows nearly 200 mi before joining the Mississippi. The USGS has operated streamflow-monitoring stations on the river since 1905. The Mission and Sandpillow housing sites lie on land near the middle reaches of the river, between the Black River Falls Dam and the Hatfield Dam (fig. 4). Recent data collections in this section of the river are shown in figure 4 and described in table 4. The water quality of the Black River was intensively monitored from 1987 to 1990 at several sites (Wisconsin Department of Natural Resources, 1992a). Significant findings included low dissolved-oxygen concentrations related to point-source discharges of phosphorus in the upper reaches of the river and elevated concentrations of certain metals at various locations (Wisconsin Department of Natural Resources, 1992a). The closest of these locations to Ho-Chunk lands is the impoundment upstream of the Black River Falls dam (fig. 4).

A fish-consumption advisory based on mercury concentrations in tissue samples is in place for Potter, White Tail, and Town Line Flowages in the Morrison Creek watershed, and for Lake Arbutus, the impoundment of the Black River above the Hatfield Dam (fig. 4). Fish-consumption advisories are modified frequently as a result of ongoing monitoring and evolving understanding of contaminant toxicology. Updated listings can be found at the WDNR website (<http://www.dnr.state.wi.us/>).

Chakh Hah Chee

The Chakh Hah Chee housing site is in Wood County, in the Cranberry Creek watershed, 1 mi east of Cranberry

Creek and 3 mi west of the Wisconsin River (fig. 6). Major land-cover types within the Cranberry Creek watershed are forest (37.2 percent), wetland (36.2 percent), grassland (11.1 percent), and agriculture (9.4 percent) (fig. 7). No water-quality data were found for Cranberry Creek.

In a report by the WDNR (1996), the authors state that “[The Cranberry Creek watershed] lacks sufficient information to be given a numerical ranking under the priority watershed evaluation process. The Juneau County Land Conservation Department (1987) listed this watershed as a priority for [wind] erosion control and improved irrigation management.” Another group studied an area east of the Wisconsin River, with similar land use and topography to the Cranberry Creek watershed, and found that wind erosion is transporting soil from crop land with associated nutrients and pesticides into streams (Golden Sands Resource Conservation and Development Area, 1993). Nineteen different pesticides were identified, including chlorinated pesticides whose use is no longer allowed. Phosphorus, nitrogen, and total solids were present at levels that could potentially impact aquatic organisms. Additionally, irrigation for agriculture may affect water quality indirectly by reducing flow during periods of ground-water pumpage (Weeks and Stangland, 1971).

Bluewing

The Bluewing housing site is in Monroe County and straddles the boundary between the Beaver Creek and Little Lemonweir River watersheds (fig. 8). In the Beaver Creek watershed, Mill Creek is the closest stream, flowing within 1 mi of Bluewing, to the northeast. In the Little Lemonweir River watershed, Mud Creek flows within 1 mi to the south of the housing site. Land-cover data for these two watersheds were combined and the major categories were: forest (34.0 percent), wetland (29.6 percent), agriculture (21.1 percent), and grassland (8.9 percent) (fig. 9). The Lower Wisconsin River Water Quality Management Plan provides some qualitative information on these streams (Wisconsin Department of Natural Resources, 1994).

Mill Creek supports a warmwater sport fishery in the vicinity of the Bluewing housing site (Wisconsin Department of Natural Resources, 1994). The WDNR describes problems with nonpoint source pollution and ditching in this section and a resulting loss of fish habitat. Mill Creek is impounded for cranberry farming immediately adjacent to Bluewing. Above these impoundments, Mill Creek is classified as a coldwater fishery. As of the last fish survey in 1968, its upper reaches sustained naturally reproducing



Mill Creek

brook trout (Cindy Koperski, Wisconsin Department of Natural Resources, written commun., 2002).

Mud Creek has similar characteristics to Mill Creek. The reach near Bluewing is impounded for cranberry farming. As mentioned in the Morrison Creek discussion, several studies suggest that dams created for cranberry farming adversely affect stream ecosystems (Avery, 1997; Greb and others, 1999; Schreiber, 1993, 1988).

Winnebago Heights, Indian Heights, and Ho-Chunk Village

Winnebago Heights, Indian Heights, and Ho-Chunk Village are in Sauk and Juneau Counties within the watersheds of Dell Creek and the Wisconsin River (fig. 10). Major land-cover types in the Dell Creek watershed are forest (45.9 percent), agriculture (30.2 percent), and grassland (13.5 percent) (fig. 11). This watershed was surveyed extensively in 1995 to provide background for the Dell Creek Priority Watershed Project (Wisconsin Department of Natural Resources, 1997).

Winnebago Heights is adjacent to a small, unnamed tributary to Dell Creek. Most small creeks in this watershed support a warmwater forage fishery (Wisconsin Department of Natural Resources, 1997). Factors affecting the water quality of Dell Creek tributaries include sediment and nutrient loading from agricultural fields and barnyards, streambank erosion, extreme low flows, and high water temperatures (Wisconsin Department of Natural Resources, 1997).

Ho-Chunk Village is near the watershed boundary of Harrison Creek, a tributary to Mirror Lake. Harrison Creek is 5.0 mi long and drains 4.97 mi². Water-quality issues in the watershed are similar to Dell Creek (Wisconsin Depart-



Gilmore Creek

ment of Natural Resources, 1997). Fish and invertebrate samples were collected by WDNR in 1995 (table 5, sites 1 and 2). CWIBI and HBI ratings were both “good” (Michael Sorge, Wisconsin Department of Natural Resources, written commun., 2002).

Indian Heights is 0.25 mi from the Wisconsin River on land that drains directly to the river. Gilmore Creek enters the Wisconsin River within 1 mi to the north of Indian Heights, after flowing 3.5 mi and draining 5.79 mi². Impairments to the quality of Gilmore Creek include sediment and nutrient loading from timber harvesting and agriculture, lack of habitat and stable substrate, and hydrologic manipulation (impoundment) (Wisconsin Department of Natural Resources, 1997). Fish and invertebrate samples were collected by WDNR in 1995 (table 5, sites 3 and 4). CWIBI ratings were “very poor” (no fish were collected) at site 4 and “fair” at site 3, while HBI ratings were “good” at both sites (Michael Sorge, Wisconsin Department of Natural Resources, written commun., 2002).

The water quality of the Wisconsin River in this vicinity is generally considered to be good, though nonpoint source pollution and sediment delivery, largely from agriculture, are problems (Wisconsin Department of Natural Resources, 1994). The river supports a warmwater sport fishery (Wisconsin Department of Natural Resources, 1994). Elevated levels of mercury and PCBs have been found in some fish in this segment of the river, resulting in consumption advisories (Wisconsin Department of Natural Resources, 2002). Recent water-quality data collections from the Wisconsin River in the vicinity of the housing sites are shown in figure 10 and described in table 5.

Summary

Water-quality data for streams in the vicinity of selected Ho-Chunk Nation residential lands were collected and summarized. The areas selected for study included streams associated with the Sandpillow, Mission, Winnebago Heights, Ho-Chunk Village, Indian Heights, Chakh Hah Chee, Bluewing, and Potch-Hah-Chee housing sites. Major rivers include the Black, Wisconsin, and Middle Branch Embarrass Rivers as well as 10 other streams.

Only a few studies contained information about the small streams in and around the Ho-Chunk housing sites. The mainstem Wisconsin and Black Rivers have been extensively studied by the WDNR (1994 and 1998). Water-quality data for the Middle Branch Embarrass River were used to calculate average values for selected water-quality constituents. Index of Biotic Integrity ratings, based on fish data, were available for five sites on three streams. Ratings were “good” at two sites, “fair” at two sites, and “very poor” at one site. Hilsenhoff Biotic Index ratings, based on macroinvertebrate data, were available for 21 sites on four streams (18 of these sites were near Potch-Hah-Chee in the Middle Branch Embarrass River watershed). Ratings were “excellent” at five sites, “good” at 14 sites, and “fair” at two sites. Summaries for each housing site focus on potential causes of water-quality problems that have often been only qualitatively evaluated. Most of these potential causes are related to agricultural activities.

Further field data is being collected for streams that have been identified by the Ho-Chunk Nation as important resources. This document will aid in an ongoing monitoring effort designed to protect these resources.

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Figures and Tables

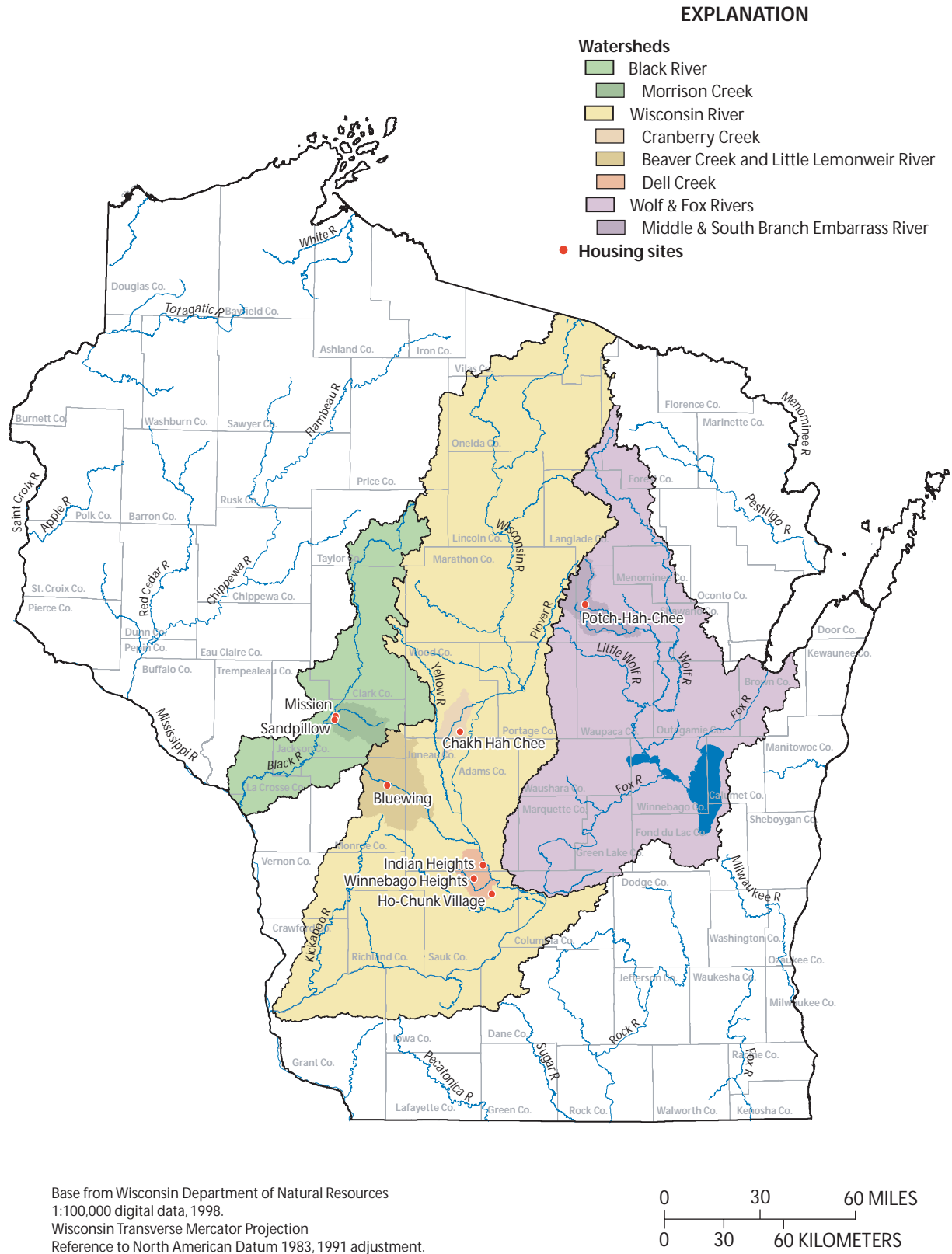


Figure 1. Ho-Chunk housing sites and watershed delineations.

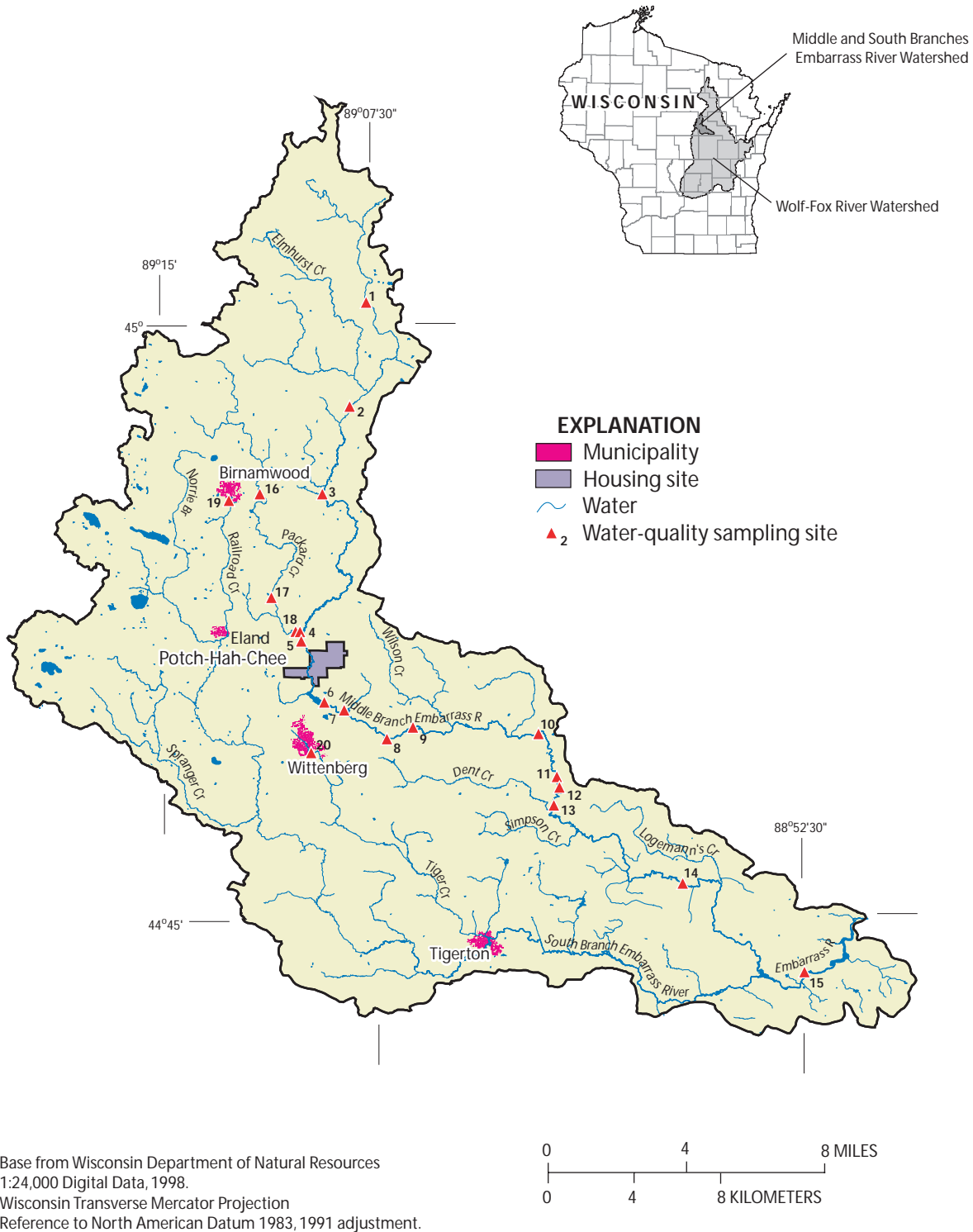


Figure 2. Water-quality sampling sites and Ho-Chunk housing site in the Middle and South Branch Embarrass River watershed (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

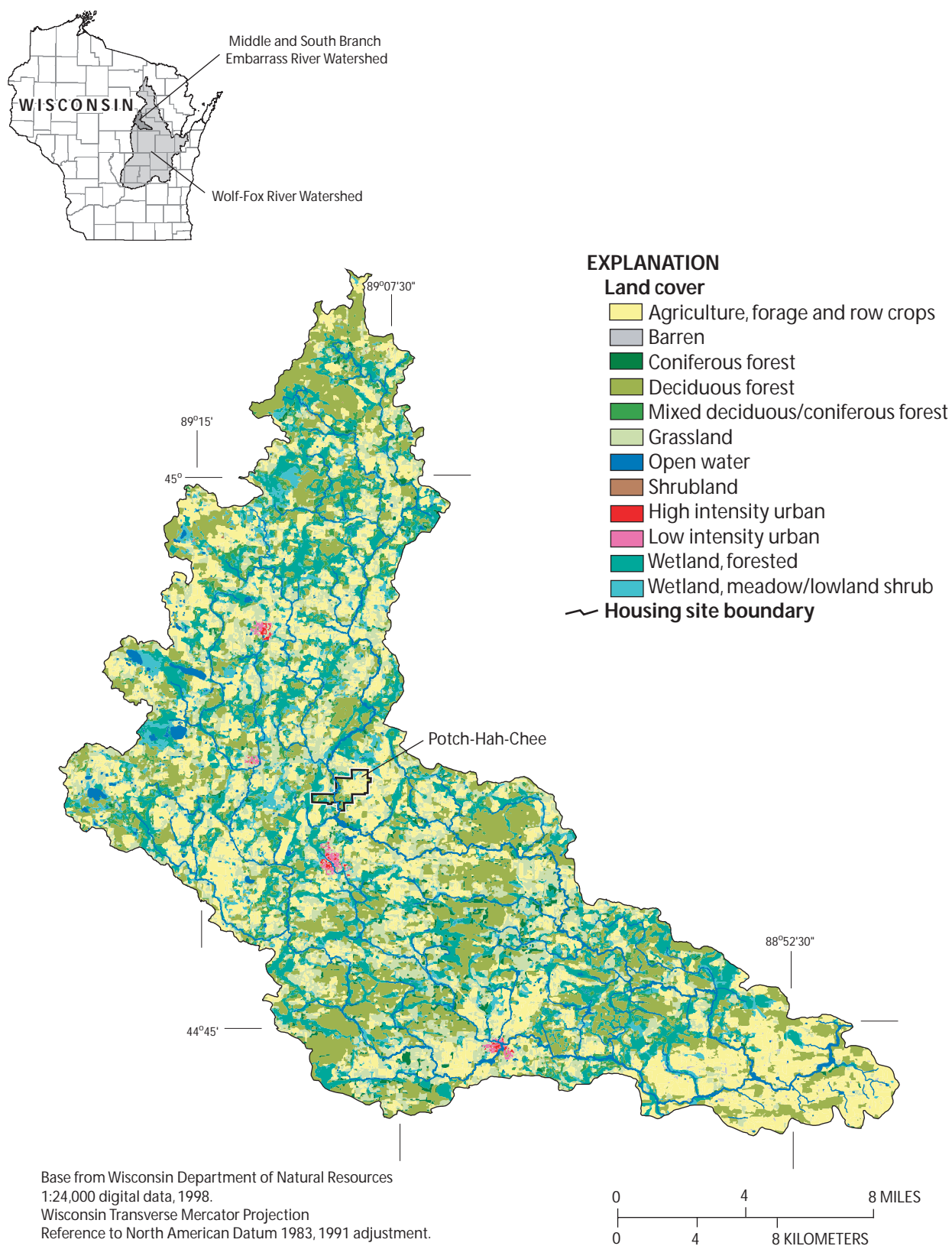


Figure 3. Land cover and Ho-Chunk housing site in the Middle and South Branch Embarrass River watershed (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).



Figure 4. Water-quality sampling sites and Ho-Chunk housing sites in the Morrison Creek watershed (Ho-Chunk Nation, unpublished data, 1999).

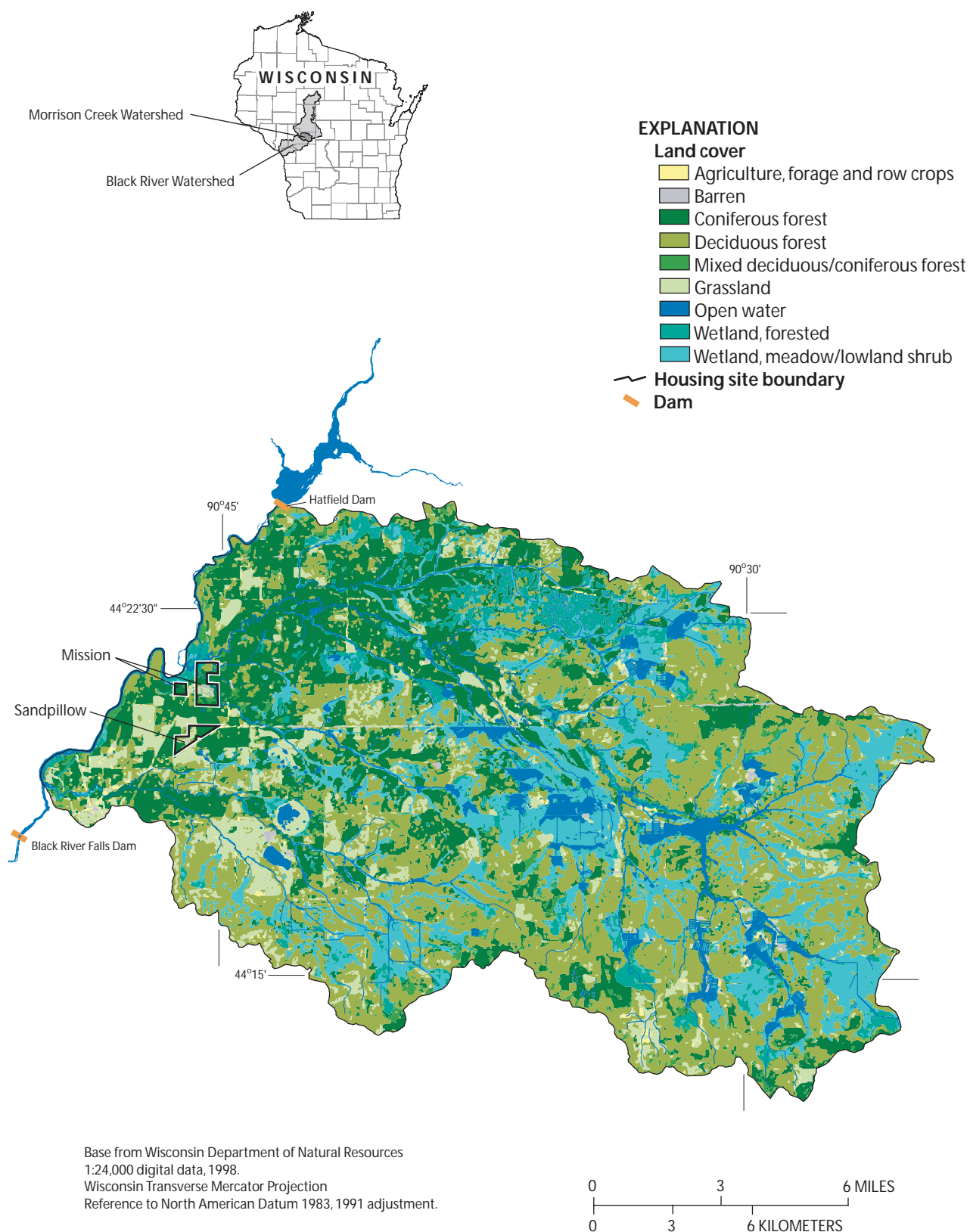


Figure 5. Land cover and Ho-Chunk housing sites in the Morrison Creek watershed (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

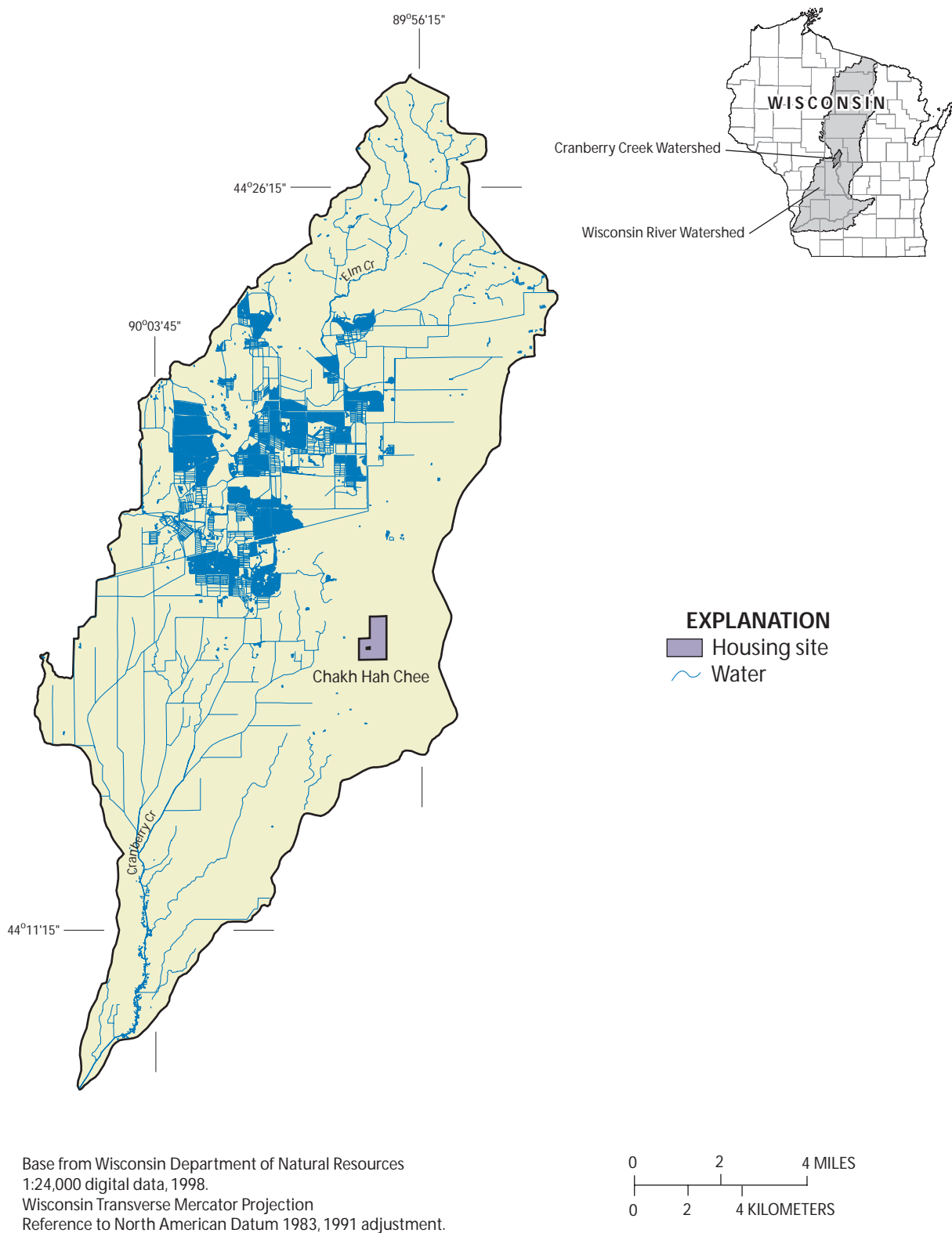
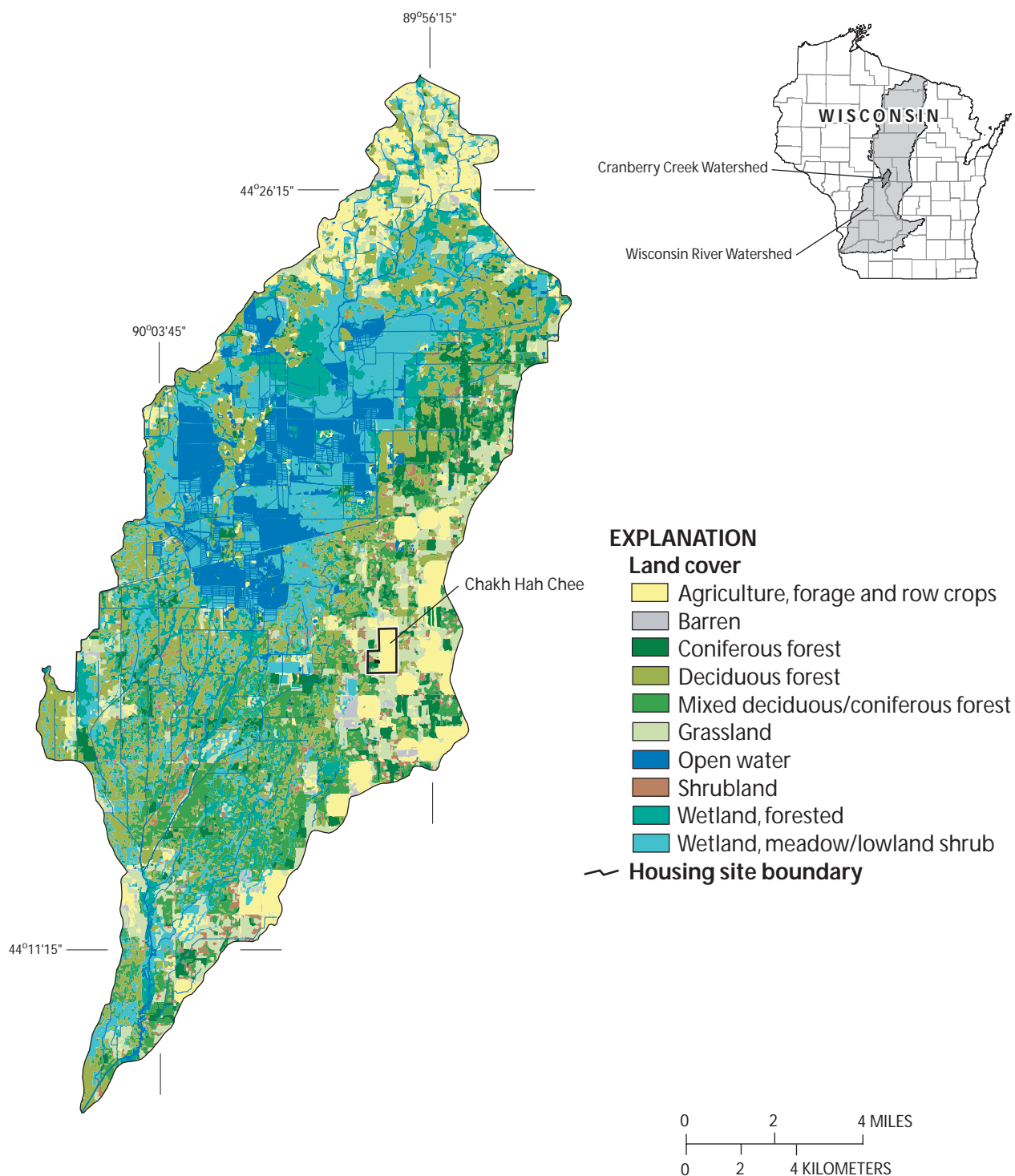


Figure 6. Ho-Chunk housing site in the Cranberry Creek watershed (Ho-Chunk Nation, unpublished data, 1999).



Base from Wisconsin Department of Natural Resources
1:24,000 digital data, 1998.
Wisconsin Transverse Mercator Projection
Reference to North American Datum 1983, 1991 adjustment.

Figure 7. Land cover and Ho-Chunk housing site in the Cranberry Creek watershed (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

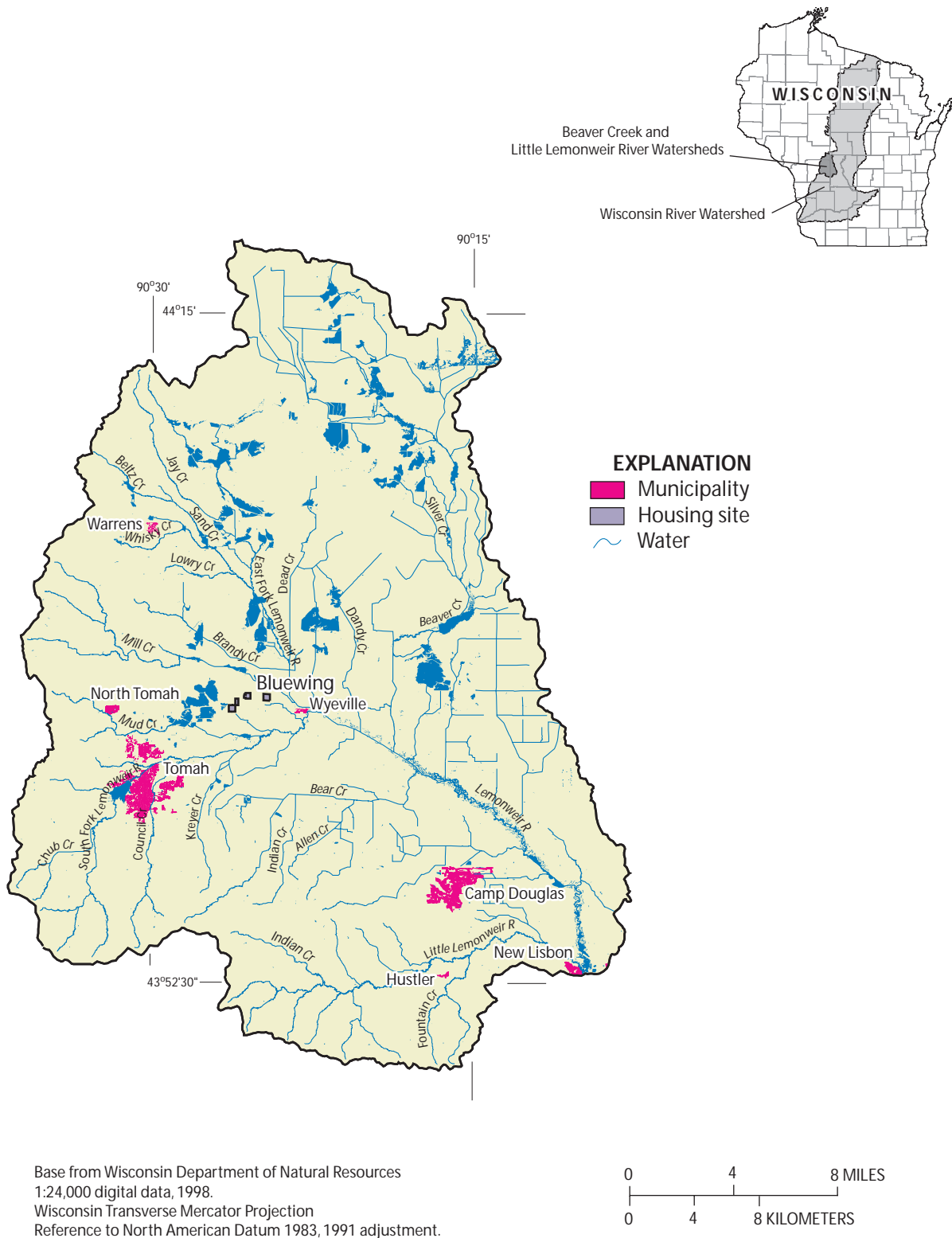


Figure 8. Ho-Chunk housing site in the Beaver Creek and Little Lemonweir River watersheds (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

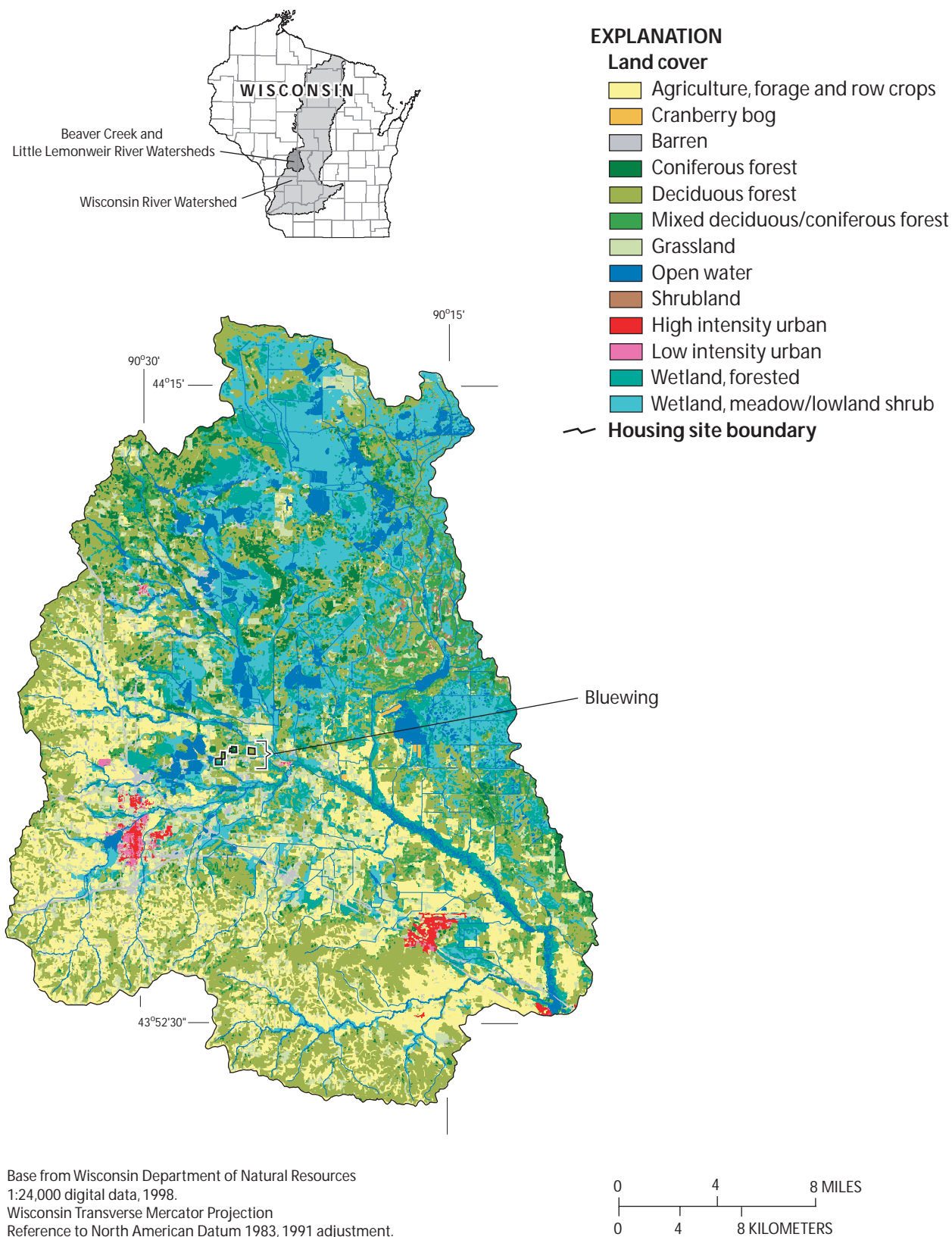


Figure 9. Land cover and Ho-Chunk housing site in the Beaver Creek and Little Lemonweir River watersheds (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

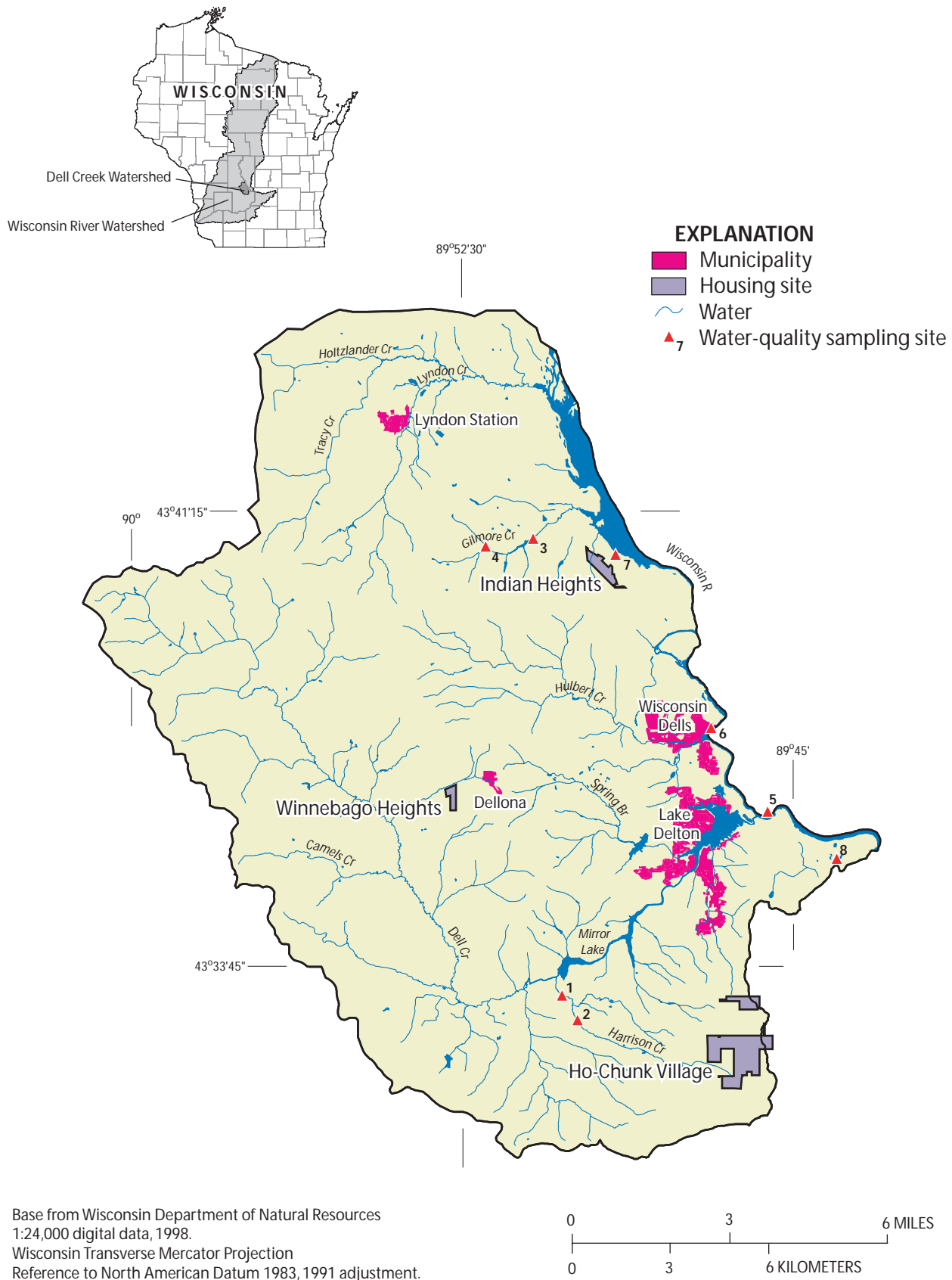


Figure 10. Water-quality sampling sites and Ho-Chunk housing sites in the Dell Creek watershed (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

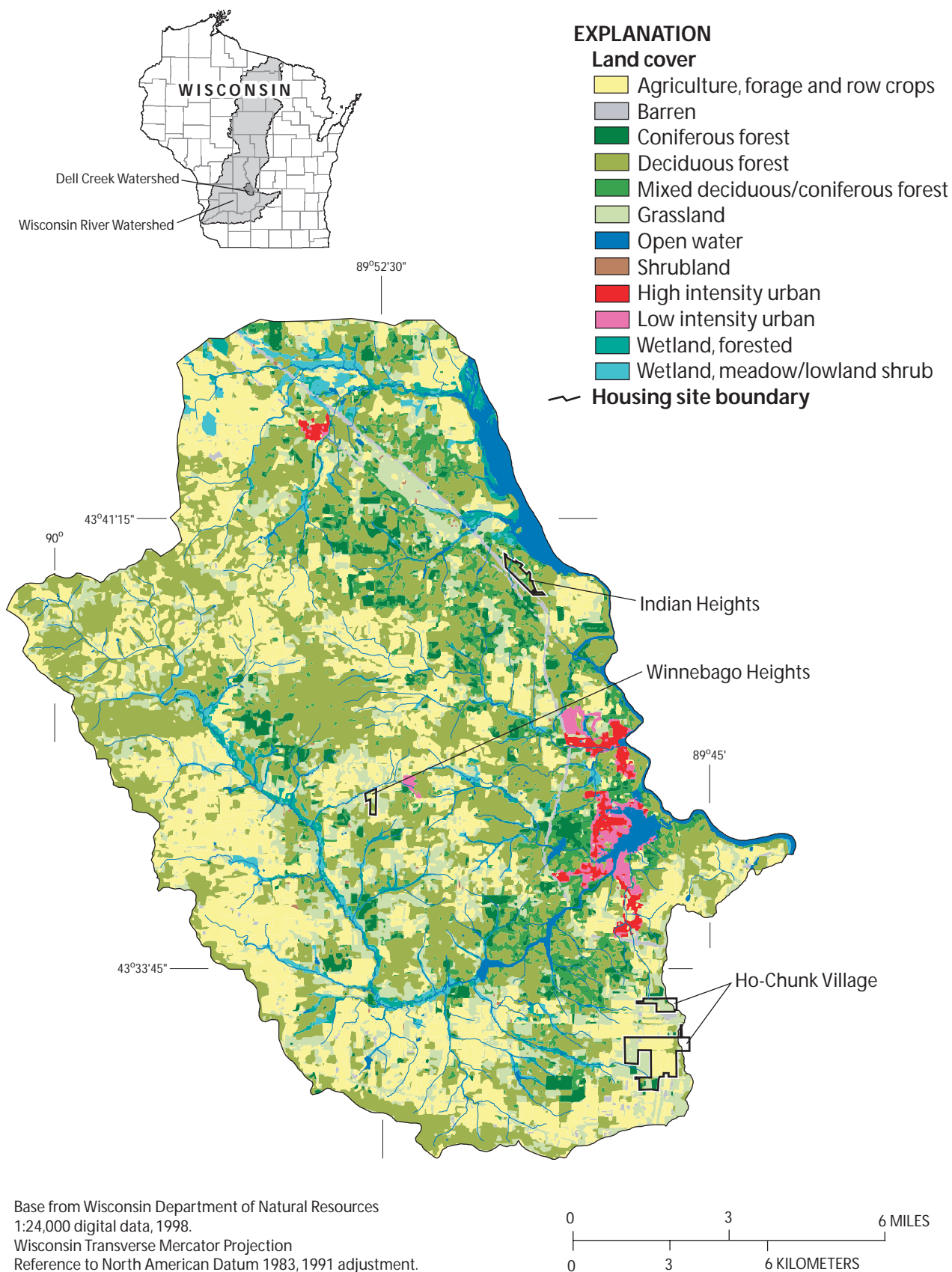


Figure 11. Land cover and Ho-Chunk housing sites in the Dell Creek watershed (modified from Wisconsin Department of Natural Resources, 1998; Ho-Chunk Nation, unpublished data, 1999).

Table 1. Locations and related waters for Ho-Chunk housing sites

[* indicates existence of previously collected water-quality data]

	Housing Sites							
	Sandpillow	Mission	Winnebago Heights	Ho-Chunk Village	Indian Heights	Chakh Hah Chee	Bluewing	Potch-Hah-Chee
County	Jackson	Jackson	Sauk	Sauk	Juneau	Wood	Monroe	Shawano
Township	21 N	22 N	13 N	12 N	14 N	21 N	18 N	28 N
Range	3 W	3 W	5 E	6 E	6 E	4 E	1 E	11 E
Section	5	33	15	3	19	24	18	34
Major rivers	Black*	Black*	--	--	Wisconsin*	--	--	Middle Branch Embarrass*
Streams	Morrison*, Dickey, Valentine*	Morrison*, Dickey, Valentine*	Dell	Harrison*	Gilmore*	Cranberry	Mill, Mud	Packard*

Table 2. Description of water-resources-related studies for Ho-Chunk housing sites and vicinities

[Housing sites: M, Mission; S, Sandpillow; W, Winnebago Heights; H, Ho-Chunk Village; B, Bluewing; I, Indian Heights; C, Chakh Hah Chee; P, Potch-Hah-Chee. Geographic scale: L, local; R, regional; S, statewide; M, multiple states.]

Text citation	Housing site	Geographic scale	Water quality	Water quantity	Sediment	Biota	Description
Avery (1997)	B, C, M, S	L, R	X	X		X	Indian (Valentine) Creek was used as a reference stream for this study on the effects of reservoirs and irrigation on Wisconsin trout streams.
Ball and Doegler (1986)	P	L	X	X		X	Contains stream survey report, along with data on fish populations, habitat surveys and macroinvertebrate communities.
Bloyd (1975)	M, S	M, R		X			A discussion of the ground-water resources of the Upper Mississippi River Basin, including the Black River.
Devaul and Green (1971)	B, C, H, I, W	R	X	X			Describes basin characteristics of Wisconsin River tributary sites.
Eswein (1995)	M, S	R				X	Includes some information on original vegetation of Jackson County, to the east of the Black River housing sites.
Fago (1983)	M, S	R				X	Contains results of annual fish sampling of the Black, Buffalo and Trempealeau river basins from 1975 to 1979.
Gebert (1971)	All	S		X			Low-flow frequency of selected Wisconsin streams.
Gebert (1982)	B, C, H, I, W	R		X			Contains flow-frequency analysis for Dell Creek, Wisconsin River, and Mud Creek.
Gebert and Holmstrom (1977)	I	L		X			Contains flow-frequency analysis for the Wisconsin River.
Golden Sands (1993)	C	R	X		X		Describes the effects of wind erosion on soils near the Chakh Hah Chee housing site.
Greb and others (1999)	B, C, M, S	R	X			X	Water-quality monitoring in Black River tributaries similar to Morrison Creek.
Hindall (1975)	H, M, S, W	S			X		Contains sediment information for the Black River and Dell Creek.
Hilsenhoff (1977)	All	S	X			X	Explains use of Hilsenhoff Biotic Index.
Ho-Chunk Nation (1999)	All	L					Digital coverage of Ho-Chunk Nation housing-site boundaries.

Table 2. Description of water-resources-related studies for Ho-Chunk housing sites and vicinities—Continued

[Housing sites: M, Mission; S, Sandpillow; W, Winnebago Heights; H, Ho-Chunk Village; B, Bluewing; I, Indian Heights; C, Chakh Hah Chee; P, Potch-Hah-Chee.
Geographic scale: L, local; R, regional; S, statewide; M, multiple states.]

Text citation	Housing site	Geographic scale	Water quality	Water quantity	Sediment	Biota	Description
Holmstrom (1979)	M, S	R		X			Provides average summer low-flow discharge for many streams in the Trempealeau and Black River Basins. Describes basin storage, infiltration, precipitation, and land cover.
Hunt and others (2000)	B	R		X			Describes water flows in an area to the east of the Bluewing housing site.
Krug and others (1992)	All	S		X			Contains flood discharge figures and recurrence intervals for gaged rivers in Wisconsin.
Lillie and Hilsenhoff (1992)	I	R	X			X	Includes insect collection site on Wisconsin River at Lake Delton.
Lippelt and Hennings (1981)	All	S	X	X			A file of county maps of water tables, aquifer boundaries and aquifer potentials. Counties of interest include Adams, Jackson, Wood and Juneau.
Lyons and others (1996)	All	S	X			X	Explains use of Fish Habitat Rating System.
Olcott (1968)	P	R	X	X			Describes characteristics of the Fox-Wolf basin.
Richards and others (1998)	P	R	X				Describes water quality of Tomorrow River, which has a similar setting to the Embarrass River.
Rose (1992)	M, S	R			X		Contains sediment data for the Black River near Galesville.
Schreiber (1988)	B, C, M, S	R	X				Summary of the impacts of cranberry farming on water resources in Wisconsin.
Schreiber (1993)	B, C, M, S	R	X			X	Describes effects of cranberry marsh discharge waters on a species of invertebrate.
Simonson and others (1994)	All	S	X			X	Explains use of Index of Biotic Integrity for Coldwater Streams,
USDA (1977)	C	R					Soils, drainage basins, surficial geology and climate information for Wood County.
USDA (1980)	H, W	R					Soils, precipitation, permeability, sanitary facilities, reservoirs, water-ways, floods, water table and hydrologic groups for Sauk County.
USDA (1982)	P	R					Soils, precipitation, permeability, sanitary facilities, reservoirs, water-ways, floods, water table and hydrologic groups for Shawano County.

Table 2. Description of water-resources-related studies for Ho-Chunk housing sites and vicinities—Continued

[Housing sites: M, Mission; S, Sandpillow; W, Winnebago Heights; H, Ho-Chunk Village; B, Bluewing; I, Indian Heights; C, Chakh Hah Chee; P, Potch-Hah-Chee. Geographic scale: L, local; R, regional; S, statewide; M, multiple states.]

Text citation	Housing site	Geographic scale	Water quality	Water quantity	Sediment	Biota	Description
USDA (1984)	B	R					Soils, precipitation, permeability, sanitary facilities, reservoirs, water-ways, floods, water table and hydrologic groups for Monroe County.
USDA (1991)	I	R					Soils, precipitation, permeability, sanitary facilities, reservoirs, water-ways, floods, water tables and hydrologic groups for Juneau County.
USDA (2001)	M, S	R					Soils, climate and land use for Jackson County.
USEPA (1986)	All		X				Contains guidelines on evaluating water-quality constituent values.
Weeks and Stangland (1971)	C	R		X			Describes effects of pumpage of ground water for irrigation on streamflow in the area east of Chakh Hah Chee.
Wisconsin Conservation Department (1966)	All	S				X	Identifies all trout waters in Wisconsin.
WDNR (1968)	P	L, R	X			X	Includes description of Embarrass River.
WDNR (1989)	P	L, R	X				Assigns Middle Branch Embarrass River a “medium priority” in the Priority Watershed Selection Procedure.
WDNR (1992a)	M, S	R	X				Identifies water-quality goals, problems, improvements and management needs for surface and ground water in the Black River Basin.
WDNR (1992b)	M, S	L				X	Field sheet for macroinvertebrate sampling of Morrison Creek.
WDNR (1994)	B, H, I, W	R	X				Contains a stream classification chart that describes general characteristics and problems of Mill, Mud, and Dell Creeks.
WDNR (1996)	C	R					Contains information on the Cranberry Creek watershed.
WDNR (1997)	H, W	L, R	X		X	X	Describes water quality of Dell Creek Watershed.
WDNR (1998a)	All	S					Digital coverage of land-cover data for Wisconsin.

Table 2. Description of water-resources-related studies for Ho-Chunk housing sites and vicinities—Continued

[Housing sites: M, Mission; S, Sandpillow; W, Winnebago Heights; H, Ho-Chunk Village; B, Bluewing; I, Indian Heights; C, Chakh Hah Chee; P, Potch-Hah-Chee. Geographic scale: L, local; R, regional; S, statewide; M, multiple states.]

Text citation	Housing site	Geographic scale	Water quality	Water quantity	Sediment	Biota	Description
WDNR (1998b)	M, S	R	X			X	Contains information on Black River subbasins, including Morrison Creek.
WDNR (2002)	All	S				X	Contains advisories for eating fish in Wisconsin.
Young and Borman (1973)	M, S	R	X	X			Discusses ground- and surface-water quality of the Trempealeau and Black River Basins.

Table 3. Summary of water-quality data collections on the Middle Branch Embarrass River and tributaries near the Potch-Hah-Chee housing site

[Site locations are shown in fig. 2. WDNR, Wisconsin Department of Natural Resources; USGS, U.S. Geological Survey; M. Br., Middle Branch; T, temperature; A, alkalinity; SC, specific conductance; Q, discharge; HBI, Hilsenhoff Biotic Index; N, total nitrogen; P, total phosphorus; I, major ions; DO, dissolved oxygen; S, suspended sediment; So, total solids; BOD, biological oxygen demand; Cl, chloride; Hab, habitat]

Site number	Latitude	Longitude	Site description	Year(s) sampled	Constituents (number of collections)														
					T	A	pH	SC	Q	HBI	N	P	I	DO	S	So	BOD	Cl	Hab
1	45° 00' 31"	89° 07' 39"	M. Br. Embarrass River at Co. Hwy. Z	1974	1	1	1	1	1										
2	44° 57' 54"	89° 08' 17"	M. Br. Embarrass River at Hemlock Rd.	1980	2				2										
3	44° 55' 42"	89° 09' 17"	M. Br. Embarrass River at Co. Hwy. N	1974	1	1	1	1	1										
4	44° 52' 14"	89° 10' 08"	M. Br. Embarrass River at Eland Rd.	1980	2				2										
				1974	1	1	1	1	1										
5	44° 52' 00"	89° 10' 05"	M. Br. Embarrass River at Hwy. 45 near Eland (USGS 04078092)	1994–95	3	2	3	3	3	3	3	2	3	3					
6	44° 50' 27"	89° 09' 18"	M. Br. Embarrass River at Panic Park in Wittenberg	1991	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
				1985	1				1					1					1
7	44° 50' 15"	89° 08' 35"	M. Br. Embarrass River at Robin Rd.	1984	1				1					1					
8	44° 49' 31"	89° 07' 05"	M. Br. Embarrass River at Cardinal Ln. (USGS gage 0407809265)	1974	1	1	1	1	1	1									
				1989–94	46				46	46									
9	44° 49' 48"	89° 06' 09"	M. Br. Embarrass River at Co. Hwy. Q	1991	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
				1985	1					1				1					1
10	44° 49' 36"	89° 01' 44"	M. Br. Embarrass River at Cemetery Rd.	1995			1	1		1				1					
				1980	2					2									
11	44° 48' 31"	89° 01' 06"	M. Br. Embarrass River at Co. Hwy. J	1995	1		1	1	1					1					
12	44° 48' 15"	89° 01' 01"	M. Br. Embarrass River at State Hwy. 29 (WDNR 593125)	1997	4	4	4	4	4				4						
13	44° 47' 48"	89° 01' 13"	M. Br. Embarrass River at Berg Rd.	1974	1	1	1	1	1										
14	44° 45' 48"	88° 56' 42"	M. Br. Embarrass River at Weasel Dam Rd.	1974	1	1	1	1	1										
				1980	2					2									
15	44° 43' 32"	88° 52' 26"	M. Br. Embarrass River at Caroline	1980	1				1										
16	44° 55' 43"	89° 11' 30"	Packard Creek at Co. Hwy. N	1980	1				1										
17	44° 53' 06"	89° 11' 07"	Packard Creek at Oriole Rd.	1980	2				2										
18	44° 52' 15"	89° 10' 16"	Packard Creek at Bluebird Rd.	1980	2				2										
19	44° 55' 33"	89° 12' 36"	Biramwood sewage treatment plant discharge to Railroad Creek (WDNR 593021)	1978–83			2				2			1					10
20	44° 49' 11"	89° 09' 46"	Wittenberg sewage treatment plant discharge to Tiger Creek (WDNR 593029)	1978–86			2				2	2							10

Table 4. Summary of water-quality data collections on the Black River and tributaries near the Sandpillow and Mission housing sites

[Site locations are shown in fig. 4. WDNR, Wisconsin Department of Natural Resources; N, total nitrogen; P, total phosphorus; I, major ions; B, bacteria; Tu, turbidity; M, metals in fish tissue; Hg, mercury in fish tissue; PCB, polychlorinated biphenyls in fish tissue; IBI, fish index of biotic integrity; Hab, habitat]

[illegible]

